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GEOCHEMICAL LABORATORY

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Thick Source Alpha Count of Some Representative Deep Sea Cores

Lamont Geological Observatory
(Columbia University)
Palisades, New York

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Task Order 18

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by

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TABLE OF CONTENTS

	page
Abstract	i
Introduction	1
Experimental	2
Results	3
Table 1 Geographical and Depth Data of Cores	4
Table 2 Surface Area - Core C-8-7	5
Table 3 Core A-157-5	6
Table 4 Core A-157-5	7
Table 5 Core A-157-13	8
Table 6 Core A-157-16	10
Table 7 $CaCO_3$ Content and Alpha Activity - Core A-152-118	11
Table 8 Surface Area and Alpha Activity - Core A-152-118	12
Conclusions	12
Bibliography	13

Abstract

Six representative deep sea cores have been analyzed for their thick source alpha emission at about every 20 cm. Some correlation can be made with calcium carbonate content but not with absolute surface area. The range of alpha activity is from 1 to 2 alphas per sq. cm. per hour for sand globigerina ooze, from 2.5 to 3.5 for foraminiferal green clay, and from 4 to 6 alphas per sq. cm. per hour for fine red clay with low foram content. It appears that total alpha activity can not be correlated simply with age as might be suggested from the Urry ionium vs. depth curves.

Thick Source Alpha Count of Some Representative Deep Sea Cores

J. Laurence Kulp, Herbert L. Volchok,
H. D. Holland, and David B. Ericson

Introduction

Some reconnaisance measurements of radioactivity of deep sea core material have been carried out by several workers (Piggot and Urry, 1941 a, b; 1942 a, b; Urry 1949; Evans, Kip and Moberg (1938) and Sanderman and Utterbeck, 1941,1948). Urry and Piggot (1941, a,b; 1942, a,b) analyzed several North and South Atlantic cores for radium content. From their data, Piggot and Urry interpreted the radium vs. depth curve in terms of ionium decay and hence suggested some tentative dates for various core depths. Since radon measurements (from which the radium content is calculated) are more difficult and time consuming than direct alpha-counting, it was thought worthwhile to apply the latter technique to several representative cores. Providing the excess ionium and its equilibrium decay products contribute a significant fraction of the total alpha activity and the uranium and thorium series concentration in the bulk sediment is reasonably constant, a curve of total alpha activity vs. depth would look like Urry's curves with a higher base line. With such a curve age estimates could be made. As the following results show, this simple picture is not observed in any of the cores measured. In spite of the negative result with regard to age determination it was considered worthwhile

to make this quantitative data available for other purposes such as stratigraphic correlation and sedimentation studies.

Experimental

The alpha activity was measured on thick sources by the scintillation method. The scintillation counting technique developed in this laboratory for low level alpha activity measurement is described elsewhere (Kulp, Holland, and Volchok, 1951). The reproducibility by this method for the counting intervals used is about 2%. Duplicate analyses were made on a large portion of the samples included in this report and in several cases 3 or 4 repeat measurements were made. The results are reported in alphas/cm^2/hr. To convert this value to α /mg/hr. involves many uncertainties including the nature of the distribution of the radioactivity and the uranium-thorium ratio and hence is not attempted until more data is available. It is not considered likely on this particular type of sediment, that the surface contamination around grain boundaries, observed by Hurley (1950) for granites, is a major problem. There are, however, other equally difficult things to consider, particularly particle size and mineral distribution. Thin source studies are in progress which make it possible to neglect the exact uranium-thorium ratio in determining the activity per unit mass.

The core samples were dried at 110°C, powdered to less than 200 mesh and placed in a circular tray within 0.5 mm of the silver activated zinc sulfide phosphor which is coated on the bottom of an RCA 5819 photomultiplier tube. Absolute calibration is obtained with a thin polonium source of known activity.

Calcium carbonate determinations by standard gravimetric procedure was carried out on certain of the samples. Surface area determination on some of the samples were made as described by Kulp and Carr (1951). Estimates of water temperature in which the sediment formed were made by Mr. Ericson based on the faunal aggregation.

Results

Table I summarizes the geographical and depth data of each of the cores studied. C-8-7 differs from the rest in being a continental shelf sample taken only about 100 miles off shore. The other samples are all from the broad, relatively flat expanse of the central North Atlantic. A 157-13, 14 and A-152-118 lie in a due north-south line with A 157-16 lying southeast between 14 and 118 and A 157-5 lying northeast of 13. If long-range stratigraphic correlation is possible, it should show up in these cores. A 157-5 is quite close and topographically similar to the Kelvin #5 core to which the Ionium Age Method was applied.

Figures 1-6 are bar graphs showing the thick source

alpha activity. This representation was chosen because the nature of sediment deposition does not necessarily follow smooth changes in composition.

Table I

Core	Lat. and Long.	Depth of Water	Length	Remarks
C-8-7	35°56'N,74°,41'W	1370 m.	495 cm.	NE of Hatteras 100 mi. off shore-shelf
A-152-118	35°07'N,44°40'W	4340	645	Due S of a-157-14 NW Flank of Mid-Atlantic Ridge
A-157-5	48°35'N,36°51'W	4500	320	43.5 km. W of Urry's core Kelvin 5
A-157-13		4680	720	167 km., N of 157-14
A-157-14		4775	490	SW Grand Banks
A-157-16		5230	317	S of Grand Banks 480 km. S of Gulf Stream, SE of A-157-14

Core C-8-7 Fig. 1 contains typical continental shelf sediments indicative of fairly rapid deposition. The total alpha activity is remarkably constant ranging from 2.57 to 3.86 α /cm^2/hr. The average activity is 3.10 α/cm^2/hr. with a mean deviation of 0.24 α /cm^2/hr. The top two-thirds of the core is a rather homogeneous green mud with warm water forams. At 335 cm. there is a sharp break in color from green to rose gray clay corresponding to a warm to cold temperature. This abrupt change is not reflected in the alpha activity. This is probably due to the bulk radioactivity being determined by the detrital material which was from a constant source. The color change was superficial, therefore, as far as the

major mineral composition is concerned.

Table 2 shows the relation of total alpha activity to surface area for selected specimens of this core.

Table 2

Core C-8-7

Depth in cm.	Surface area m^2/gm	$\alpha/cm^2/hr.$
26	10.5±0.4	3.31
53	12.7±0.5	2.90
99	12.1±0.5	3.00
130	11.7± 0.5	2.89
145	12.5±0.5	3.08
188	10.3±0.7	2.93
227	11.1±0.4	2.90
330	14.0±0.5	3.22
340	15.5±0.5	3.30
343	10.7±0.4	3.30
361	17.3±0.5	2.60
487	12.6±0.5	3.85

It is clear from the data that there is no correlation of surface area of the particles with alpha activity. This suggests that the major fraction of the activities lies within the particles rather than appearing on the surface. This in turn indicates that any adsorption process contributes in only a minor way to the total activity of this type of sediment. Such an adsorption process is probably occurring

(Holland and Kulp, 1952) but is masked by the bulk activity.

Core A-157-5 is the northernmost one of the remaining five from the north Atlantic basins and was chosen for study due to its proximity to the core studied by Urry and Piggott (1941).

The first 75 cm. consists of a homogeneous foraminiferal gray clay with the exception of a sand layer at 25 cm. The total alpha activity in this homogeneous section of the core seems directly related to the temperature of deposition as is shown in Table 3.

Table 3

Depth (cm.)	Cold-Warm Faunal Ratio	$\alpha/cm^2/hr.$
15	2.12	3.36
65	1.86	3.15
55	1.50	3.05
10	1.50	3.05
30	0.82	2.85
40	0.82	2.80
45	1.00	2.80

It was noted specifically in the first 20 cm. depth that the foram concentration decreased regularly with decreasing temperature. Since it is known that the foram shells contain relatively little radioactivity, the increase in alpha activity in the first 20 cm. is due to the decrease in the foram concentration which is determined by temperature. This relationship between alpha activity and foram content appears to have general validity providing a homogeneous foraminiferal clay section is considered.

The low activity at 25 cm. is due to the presence of a

clear sand layer, 2 cm. in thickness.

Around 100 cm. the sharp variations in alpha activity appear related to the sand concentration. At 100 cm. the sediment consists of about 95% heterogeneous sand with pebbles up to 4 mm. in diameter while mechanical analyses of samples at 90 cm. showed 50% sand, and at 110 cm. showed 40%. While these mechanical analyses were not done on exactly the same depth as the alpha count, the general trend is considered significant.

From 120 cm. to the bottom of the core the sediment consists of a reasonably uniform foraminiferal clay with minor variations. No correlation of the alpha count at 243 and 248 cm. could be made with existing data.

It seems that this core is relatively homogeneous in broad aspect and should therefore be useable for age determination by the ionium method. Radon measurements are now being carried out on this core to study this possibility.

Some surface area data is also available for this core. It is compared with the alpha activity in Table 4.

Table 4

Core A-157-5

Depth in cm.	Surface Area m^2/gm	$\alpha/cm^2/hr.$
10	18.8	3.20
23	27.8	2.69
43	22.5	2.85
63	24.5	3.14
84	28.8	3.27
112	32.7	3.00
155	18.3	2.58
186	14.2	2.56
222	31.1	2.97
248	17.8	2.52

Again it is clear that the correlation of surface area with alpha activity is negative even though the surface areas are considerably higher on the average than in core C-8-7. The same conclusions apply.

Core A-157-13 is next in line to the southwest 1520 km. There is no apparent stratigraphic correlation between the two cores either in alpha activity or lithologic types. In general the alpha activity is double that in core A 157-5. This core is relatively inhomogeneous down to 270 cm.

From 200 cm. the sediment is a foraminiferal clay with varying sand concentration. In this zone it appears that the alpha activity is to be correlated with sand content as is shown by the data of Table 5.

Table 5

Core A-157-13

Depth (cm.)	Sand concentration %	$\alpha/cm^2/hr.$
180	95	2.42
60	85	2.59
160	20	3.87
40	15	4.40
140	1-2	4.56

In this section there are also two thin layers of globigerina ooze but these were not alpha counted. The sample at 215 cm. lies in a globigerina ooze layer and thus might be expected to be low in activity. The sample at 240 cm. consists largely of foram shells and sand grains. From 273 cm. down the core consists primarily of a green silty clay with a few sandy layers such as at 295, 400, 505, 660 and 680 cm. Again

it appears that the total thick source alpha activity is reasonably constant for a constant sediment type but that is directly affected by carbonate shells and sand. The extent of the effect can be predicted qualitatively.

The contact between the two sediment types at 273 cm. is so sharp that it could represent an unconformity. This break is also distinct in the alpha activity. (See Fig. 3)

Core A-157-14 lies 201 km. directly south of A-157-13. The top 10 cm. of this core is a globigerina ooze with an alpha activity below 3 $\alpha/cm^2/hr$. The 10-150 cm. section consists of a fairly homogeneous foraminiferal clay which shows a suggestion of an Urry type curve. At 150 cm., the sediment becomes a globigerina ooze with considerable variation in clay content until the green silty clay begins to come in at 275 cm. alternating with thin layers of red foraminiferal clay. At 340 cm. an impure sand occurs with an α activity of 3.24 $\alpha/cm^2/hr$. which compares closely with the activity of similar sand layers (295 cm., 660 cm.) in the green silty clay section of core A-157-13. Below 350 cm. the core consists of a homogeneous silty green clay very similar to the lower part of A-157-13 and is probably correlative with it. Except that it contains more forams which may suggest why the alpha activity for this section ranges from 4 to 4.5 $\alpha/cm^2/hr$. instead of 4-6 $\alpha/cm^2/hr$. as in A-157-13.

Core A-157-16 consists of a pink to gray foraminiferal

clay. Some inhomogeneity is observed in the first 30 cm. At 30 cm. depth there is a lithologic break which is reflected in the alpha activity. Another such break occurs at about 53 cm. which is not as evident in the alpha activity.

The alpha activity ranges from 3-5 $\alpha/cm^2/hr$. There is a downward trend from 30 cm. to the bottom of the core. This suggests an ionium decay curve. This core appears to have been taken south of the glacial zone; since it is long enough to be Wisconsin, but does not contain Glacial marine layers. Compared to A-157-13 and 14 this core is quite homogeneous.

Table 6 shows some carbonate data obtained on this core.

Table 6

Core A-157-16

Depth in cm.	% Ca CO_3	$\alpha/cm^2/hr.$
5-6	15	3.45
11-12	26	3.35
16-17	28	3.21
23-24	26	3.56
27-28	19	5.25
31-32	26	4.80
36-37	29	4.25
44-45	28	4.00
52-53	6	4.75
64-65	8	4.20
71-72	22	4.05
84-85	10	4.22
91-92	9	3.69
103-104	13	4.20

It is evident that in this core other factors are more important in determining the total alpha activity than the fluctuation of calcium carbonate from 6-29%.

Core A-152-118 is located 501 km. south of A-157-14. The top 30 cm. consists of a clayey globigerina ooze. From 30-80 cm. the sediment is a reddish calcareous clay which changes to a gray-white clayey ooze to 270 cm. A similar clay with a faint pink color occurs 270-300 cm. then turns gray 300-340 cm. From 340-490 cm. the core is a pink to red calcareous clay with abundant forams.

In these sections of core, a correlation can be shown between the calcium carbonate content and the alpha activity (Table 7) providing samples with identical lithology are compared.

Table 7

$CaCO_3$ Content and Alpha Activity

Core A-152-118

Depth in cm.	$CaCO_3$ %	α/cm.^{2}/hr.
	Red Calcareous Clay (few forams) (30-80cm.)	
30	48	4.00
80	30	4.41
40	25	4.93
	Gray-white clay ooze (80-270)	
263	45	2.89
162	45	2.77
180	35	3.25
200	32	3.40
	Pink Calcareous Clay (abundant forams) (350-442 cm.)	
370	52	2.00
360	45	2.23
350	45	2.39
442	40	2.42
420	35	2.78
400	25	3.59

Table 8 shows some surface area data for this core.

Table 8

Core A-152-118

Surface Area and Alpha Activity

Depth in cm.	Sample Area m^2/gm	$\alpha/cm^2/hr.$
30	34.1	4.00
40	29.7	4.95
52	27.1	4.3
75	32.5	3.8
147	23.3	7.0
162		2.7
181	21.7	3.1
200	23.7	2.9
263	25.3	3.0
283	22.1	2.8
305	18.0	3.8
321		2.4
350		2.2
360	15.8	2.2
380	18.8	2.0
400	30.1	3.7
410	24.2	2.8
442		2.4

Again it is clear that the total alpha activity is determined by the radioactive elements within mineral grams, not on the surface.

Conclusions

It can be concluded from this series of data that total alpha activity is not sufficient for age determination by the ionium method. Further, it appears that although certain distinct sediment types have distinct total thick source alpha activity ranges, there is considerable overlap; and that the actual alpha activity measured is determined to a large extent by such random features as the percent of foraminiferal shells, the

concentration and radioactivity of the sand grains, and the composition of the particular clay type. It appears that the greatest determinant of α activity, is the mineral composition of the particles. Limited qualitative correlation is possible, between the total α activity and both $CaCO_3$ content or sand content, both, however, being limited to zones of similar lithology. In the cases of A-157-13, A-157-14 and A-152-118, A-157-16, comparison of the sediment type and the alpha activity at a certain depth does not show clear stratigraphic correlation except for the distinctive green silty clay which appears at 339 cm. in A-157-14 and at 273 cm. in A-157-13. This may be due to the fact that the cores were taken at too great a distance from each other. It should be noted, however, that since the alpha activity varies considerably outside the experimental error it would seem that stratigraphic correlation by such a method might be possible if cores sufficiently close in geographic location were studied.

Bibliography

(1). Evans, R.D., Kip, A.F. and Moberg, E.G.; The Radium and Radon Content of Pacific Ocean Water, Life and Sediments, Am. Jour. Sci. 5th Series, vol. 36 p. 255 (1938)

(2). Holland, H.D. and Kulp, J.L.; Mechanism of the Removal of Radioelements from the Ocean, (in preparation)

(3). Kulp, J.L., Holland, H.D. and Volchok, H.L.; Low Level Alpha Counting on Rocks and Minerals by the Scintillation Method, (in press for 1951) Trans., Am. Geophys. Union

(4) Piggot and Urry; Radioactivity of Ocean Sediments III, A.J.S. vol. 238 p. 81 (1941)

(5) Piggot and Urry; Radioactivity of Ocean Sediments IV, A.J.S. vol. 240 p. 1 (1942)

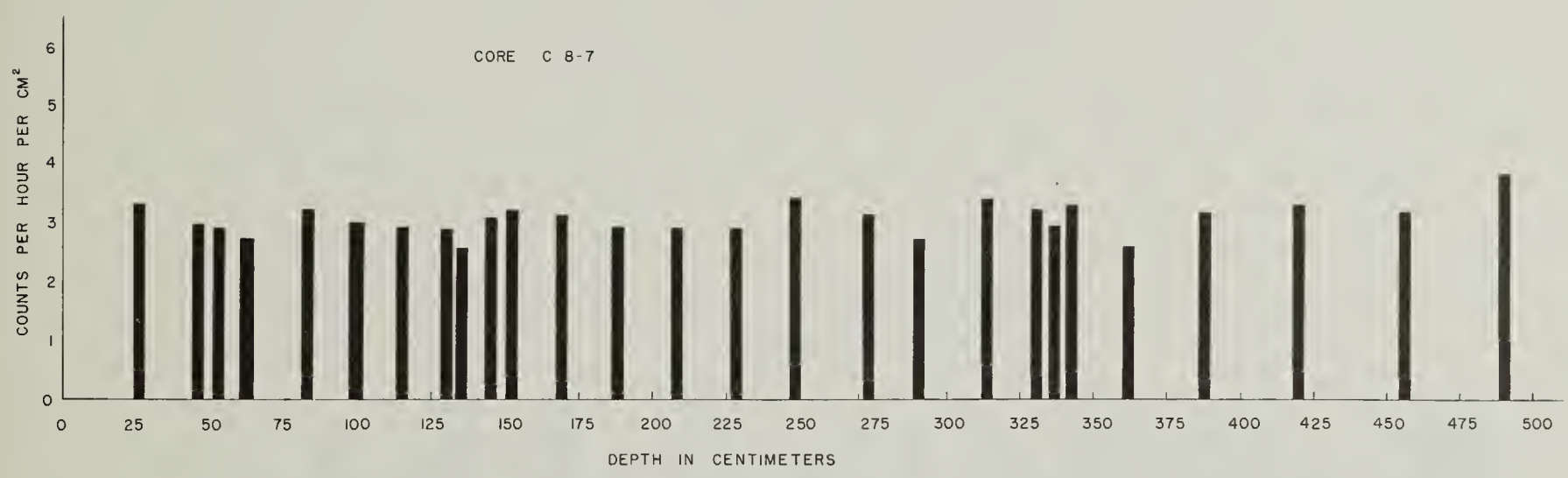
(6) Piggot and Urry; Time Relations in Ocean Sediments, Bull. G.S.A. vol. 53 p. 1187 (1941)

(7) Sanderman, L.A. and Utterbeck, C.L.; Radium Content of Ocean Bottom Sediments from the Arctic Ocean, Bering Sea, Alaska Peninsula, and the Coasts of Southern Alaska and Western Canada, J. Mar. Res. vol. 4 p. 32 (1941)

(8) Urry and Piggot; Radioactivity of Ocean Sediments V, A.J.S. vol. 240 p. 93 (1942)

(9) Urry; Radioactivity of Ocean Sediments VI, A.J.S. vol. 247 p. 257 (1949)

(10) Utterbeck, C.L. and Sanderman, L.A.; Radium Analyses of Marine Sediments in Northern Pacific and Adjacent Waters, J. Mar. Res. vol. 7 p. 635 (1948)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2
3
4
5
6
0
25
50
75
100
125
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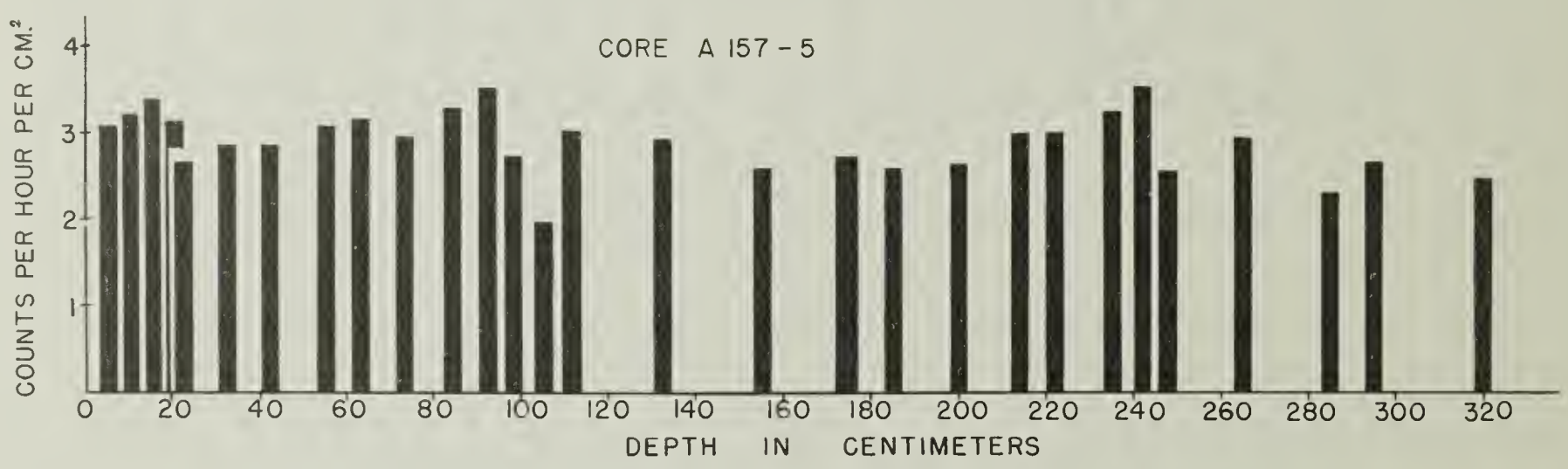
300
325
350
375
400
425
450
475
500
DEPTH IN CENTIMETERS

Figure 1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140
160
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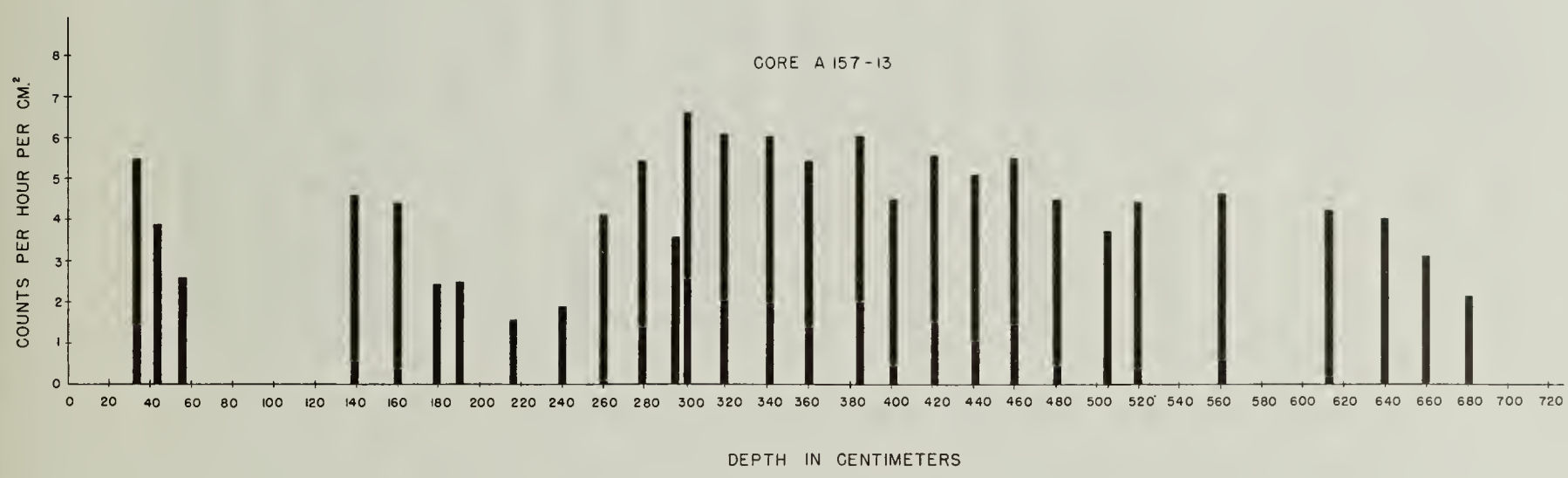
200
220
240
260
280
300
320
DEPTH IN CENTIMETERS

Figure 2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2
3
4
5
6
7
8
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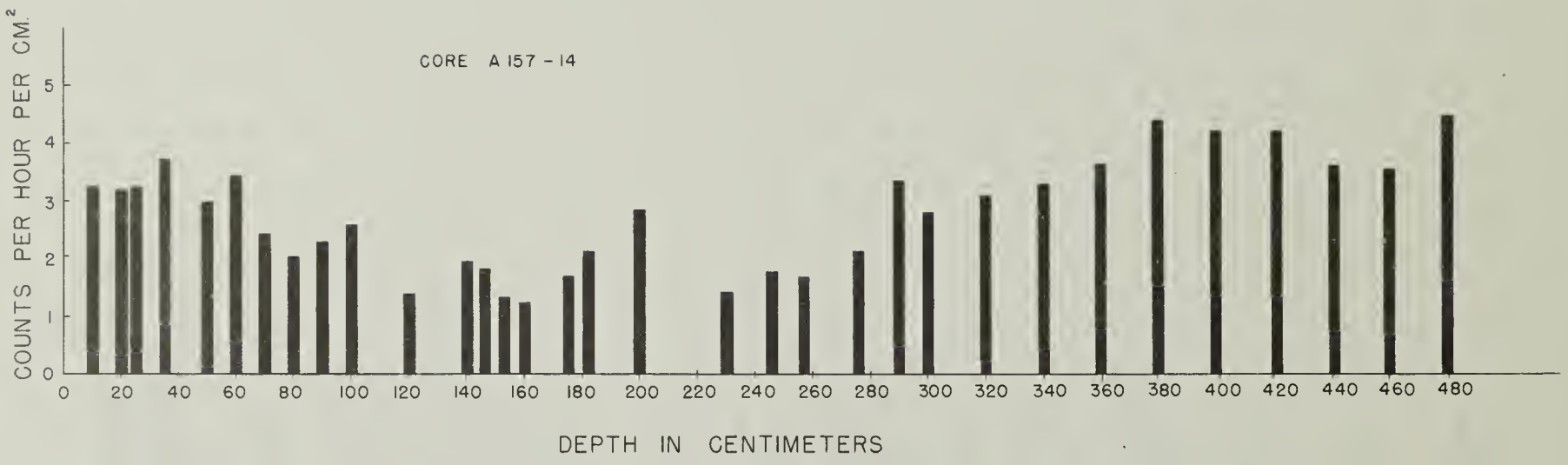
DEPTH IN CENTIMETERS

Figure 3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COUNTS PER HOUR PER CM.²
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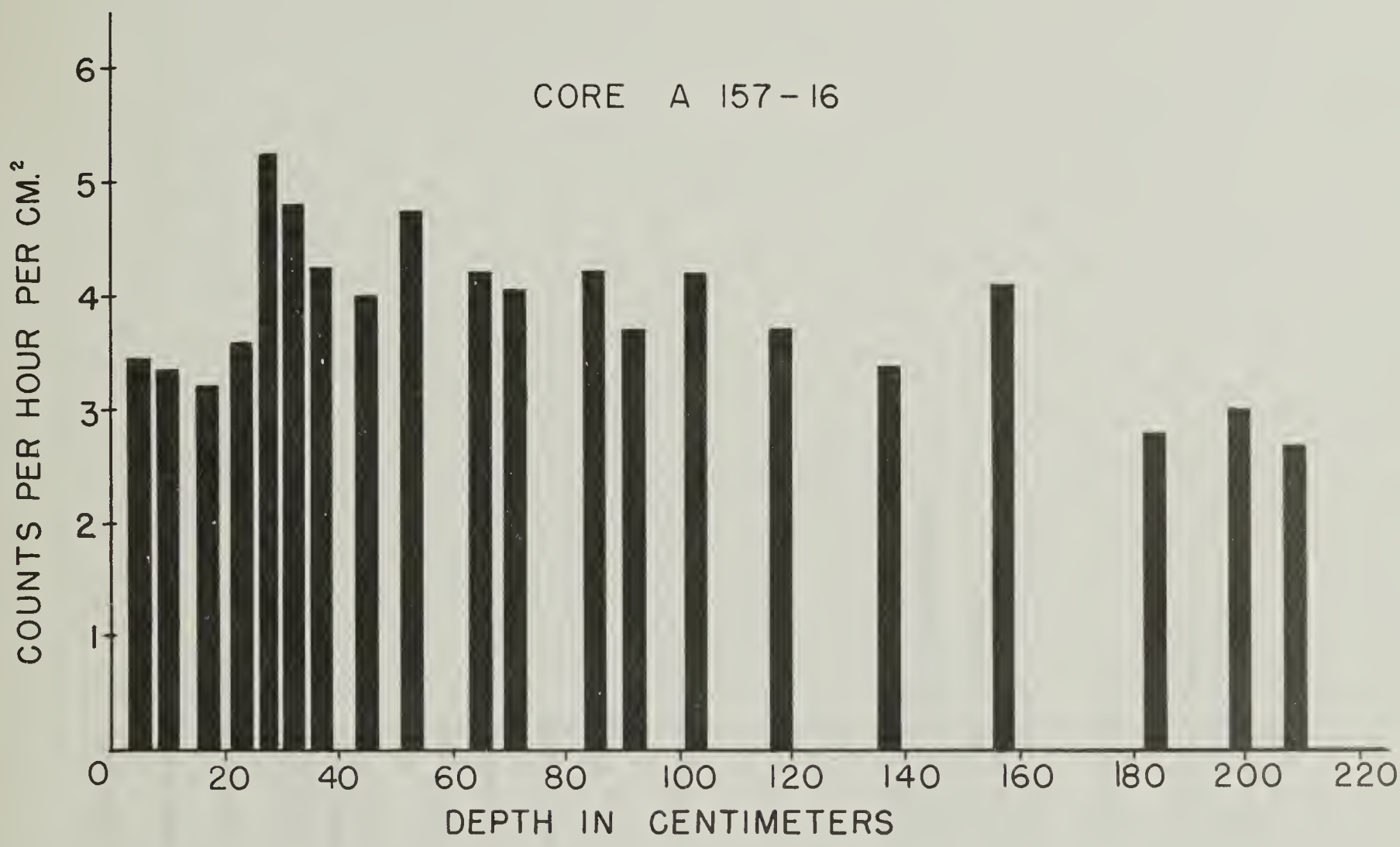
DEPTH IN CENTIMETERS

Figure 4


CORE A 157-16
COUNTS PER HOUR PER CM.²
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20
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60
80
100
120
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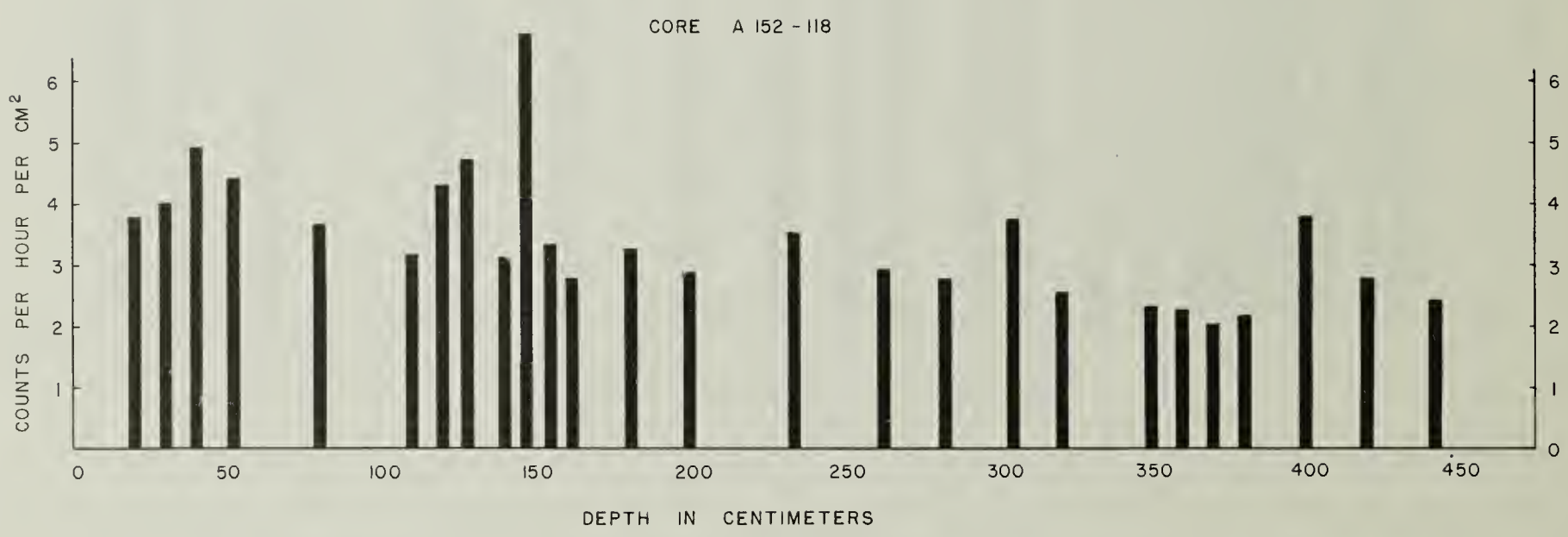
160
180
200
220
DEPTH IN CENTIMETERS

Figure 5


CORE A 152 - 118
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1
2
3
4
5
6
0
50
100
150
200
250
300
350
400
450
DEPTH IN CENTIMETERS

Figure 6

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